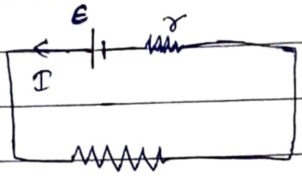
Lecture-4 Electromotive force & ohm's law

★ Electromotive force (emf) - ε is the potential difference between the +ve and -ve electrodes in an open circuit



$r \rightarrow$ internal resistance of a cell/battery

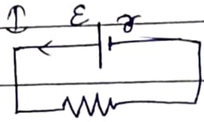
$V = IR$

$V = \varepsilon - Ir$

$IR = \varepsilon - Ir$

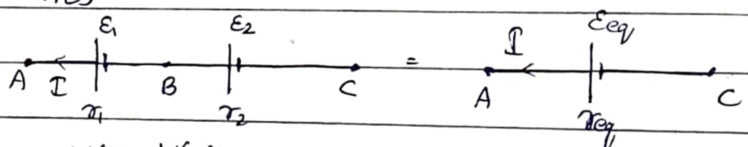
$I(R+r) = \varepsilon$

$I = \dfrac{\varepsilon}{R+r}$



★ Cells in series and parallel

① Series



$V_{AB} = V(A) - V(B) = \varepsilon_1 - Ir_1$

$V_{BC} = V(B) - V(C) = \varepsilon_2 - Ir_2$

$V_{AC} = V(A) - V(C) = V(A) - V(B) + V(B) - V(C)$

$= V_{AB} + V_{BC} = \varepsilon_1 - Ir_1 + \varepsilon_2 - Ir_2$

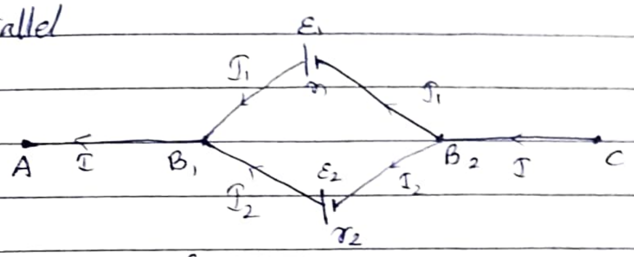
$= (\varepsilon_1 + \varepsilon_2) - I(r_1 + r_2)$

$V_{AC} = \varepsilon_{eq} - I r_{eq}$

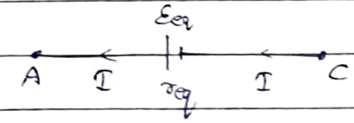
$\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2$ $\qquad r_{eq} = r_1 + r_2$

- Equivalent emf of a series combination of n cells is just the sum of their individual emf's
- The equivalent internal resistance of a series combination of n cells is just the sum of their internal resistance

② Parallel



≡



$$I = I_1 + I_2$$

$$V \equiv V(B_1) - V(B_2) = \varepsilon_1 - I_1 r_1$$

$$V \equiv V(B_1) - V(B_2) = \varepsilon_2 - I_2 r_2$$

$$I = I_1 + I_2$$

$$= \frac{\varepsilon_1 - V}{r_1} + \frac{\varepsilon_2 - V}{r_2} = \left(\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}\right) - V\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

$$V = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} - I \frac{r_1 r_2}{r_1 + r_2}$$

$$V = \varepsilon_{eq} - I r_{eq}$$

$$\varepsilon_{eq} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} \qquad r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$$

$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2}$$

$$\frac{\varepsilon_{eq}}{r_{eq}} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}$$

For n cells

$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} + \cdots + \frac{1}{r_n}$$

$$\frac{\varepsilon_{eq}}{r_{eq}} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} + \cdots + \frac{\varepsilon_n}{r_n}$$